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FIREPLACE HYDRONIC HEATING

Background of the Invention

Field of the Invention

The present invention generally relates to hydronic heating systems, and more particularly relates to hydronic heating systems that include a fireplace as a source of heat.

Related Art

The use of closed loop liquid systems for the purpose of transferring heat generated within a heating appliance to a remote location for radiant convection of a surrounding area is well-known in the art. Liquid-based heating systems can be more efficient than air-based heating systems in many cases and may be particularly useful for scavenging otherwise lost heat from an existing air-based heating system. Liquid-based heating systems are often referred to as hydronic heating systems and typically include a liquid-filled conduit positioned next to a source of heat whereby the heat is absorbed into the liquid, the heated liquid is transferred to a remote location, and the heat is removed from the liquid at the remote location.

One common hydronic heating system includes a boiler as the source of heat. Boilers are designed specifically for heating the liquid to a predetermined temperature and pumping the liquid to a heat exchanger, such as a radiator, that is positioned somewhere in living space to be heated. Other hydronic heating systems utilize a fireplace as a source of heat. In one example fireplace hydronic system, the liquid-filled conduit extends through the fireplace grate, and the liquid is heated by heat generated by burning a combustible fuel on or around the grate. The heated liquid is then pumped to a suitable heat exchanger that is part of a forced-air heating system or mixed with a cold water supply that feeds a hot water heater. In another known fireplace hydronic heating system, the liquid passes through a fireplace jacket that extends around the combustion chamber enclosure of the fireplace. The water heated in

the jacket is then transferred to a remote location where the heat is removed in a heat exchanger.

A common problem associated with fireplace hydronic heating systems is undesired condensation buildup on the structure holding the liquid due to the temperature differential between the cool liquid and the heated air generated by the fireplace. Typically, a metal or metal alloy material is used for the conduit or jacket that holds the liquid to be heated in or around the fireplace combustion chamber enclosure. When heat is initially generated in the fireplace, humidity in the fireplace collects as condensation on the structure holding the liquid because the structure is being cooled by the cool liquid. This condensation is aesthetically undesirable and may adversely effect functions of the fireplace. Further, if the condensation occurs on the outside of the combustion chamber enclosure, for example within an interior wall of the building in which the fireplace is mounted, the condensation may result in damage to the building structure.

A hydronic heating system that addresses these and other shortcomings of known hydronic heating systems would be an advance in the art.

Summary of the Invention

The present invention generally relates to hydronic heating systems, and more particularly relates to fireplace hydronic heating systems that are designed to eliminate condensation and improve manufacturability of the hydronic heating system.

One aspect of the invention relates to a hydronic heating system that includes a conduit configured to carry a heat conductive liquid, and a panel integrally formed together with a portion of the conduit. The panel is configured to absorb heat from a heat source and transfer the absorbed heat to the liquid in the conduit. The heated liquid may be transferred to a remote location where the heat is removed from the liquid using, for example, a heat exchanger. The panel and the portion of the liquid-filled conduit may be integrally formed using a moldable material such as a ceramic fiber and a binder, and using such processes as compression and vacuum molding. The

use of some moldable materials may substantially eliminate condensation in or around the combustion chamber enclosure.

Another aspect of the invention relates to a method of manufacturing a hydronic heating system that includes a panel and a liquid-filled conduit. The method includes the steps of forming the panel from a heat conductive moldable material, and encapsulating a first portion of the conduit in the panel. The method may also include forming the system panel in a panel of a combustion chamber enclosure and encapsulating a portion of the conduit in a panel of the combustion chamber enclosure. The method may also include generated heat in the combustion chamber, absorbed the generated heat into system panel, and transferring the absorbed heat into the liquid in the conduit. The method may also include encapsulating a portion of the conduit in two or more panels of the combustion chamber enclosure.

A yet further aspect of the invention relates to a hydronic heating system for a fireplace that includes a combustion chamber enclosure having a plurality of panels defining a combustion chamber for the combustion of fuel to generate heat, and a heat exchanger. The heat exchanger includes a molded panel and a liquid-filled conduit. A portion of the liquid-filled conduit is integrally formed within the molded panel and the molded panel is positioned adjacent to the combustion chamber enclosure.

The above summary of the present invention is not intended to describe each disclosed embodiment or every implementation of the present invention. Figures in the detailed description that follow more particularly exemplified embodiments of the invention. While certain embodiments will be illustrated and described, the invention is not limited to use in such embodiments.

Brief Description of the Drawings

The invention may be more completely understood in consideration of the following detailed description of various embodiments in the invention and in connection with accompanying drawings, in which:

Figure 1 is a schematic representation of an example hydronic heating system according to principles of the invention;

Figure 2 is a top view of an example fireplace hydronic heating system according to principles of the present invention;

Figure 3 is a cross-sectional view of the fireplace hydronic heating system shown in Figure 2 taken along cross-sectional indicators 3-3;

Figure 4 is a rear view of another example fireplace hydronic heating system having liquid-filled conduits included in the top, side and rear panels of the fireplace;

Figure 5 is a side view of the example fireplace hydronic heating system shown in Figure 4;

Figure 6 is a cross-sectional view of the example fireplace hydronic heating system shown in Figure 4 taken along cross-sectional indicators 6-6;

Figure 7 is a cross-sectional view of another example fireplace hydronic heating system with the liquid-filled conduits positioned on an exterior of a heated air plenum of the fireplace; and

Figure 8 is a cross-sectional view of another example fireplace hydronic heating system with the liquid-filled conduits positioned adjacent to an interior surface of the combustion chamber enclosure.

While the invention is amenable to various modifications and alternate forms, specifics thereof have been shown by way of example in the drawings and will be described in detail. It should be understood, however, that the invention is not limited to the particular embodiments described. On the contrary, the invention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention.

Detailed Description of the Preferred Embodiment

The present invention generally relates to hydronic heating systems, and more particularly relates to an improved fireplace hydronic heating system that is capable of eliminating condensation and improve manufacturability of the hydronic heating system. While the example embodiments of the present invention provided below are described in conjunction with example fireplaces, the present invention is

equally applicable to other heating systems or appliances that generate heat for the purpose of heating a living space. Some example fireplaces that may be used in accordance with principles of the present invention include a direct vent, a universal vent, a B-vent, a horizontal/vertical-vent, a dual direct vent, and a multi sided unit having two or three glass panels as combustion chamber side panels.

As used herein, the phrase "combustion chamber enclosure" may include any structure that at least partially encloses a space in which heat is generated from combusting a material, solid, or gas, activating an electric heating element, or a flame is simulated. The phrase "transferring heat" may include either convection or conduction heat transfer. A "heat source" may include, for example, an electric or gas (e.g., natural gas or hydrogen gas) heater or a combustible solid fuel such as wood or wood pellets. The term "hydronic" is generally defined as referring to any liquid and is not limited to the use of water as the liquid. The term "conduit" is generally defined as a passage having an inlet and an outlet and is capable of carrying a fluid between the inlet and the outlet.

Figure 1 is a schematic representation of an example hydronic heating system 10 according to principles of the invention. System 10 includes a heating appliance 12, a first heat exchanger 14, a pressure regulating tank 16, first and second pumps 18, 20, a pressure release valve 22, and second and third heat exchangers 24, 26. The heating appliance 12 is shown as a fireplace that includes a combustion chamber enclosure 30 having top and bottom panels 32, 34, first and second side panels 36, 38, and a rear panel 40 that define a combustion chamber 42. The heating appliance 12 also includes a fuel input 44, an exhaust vent 46, and a combustion air inlet 48. The first heat exchanger 14 includes a plurality of liquid-filled conduits 50 associated with the top panel 32 of the combustion chamber enclosure 30. The liquid-filled conduits may be defined by a pipe member having any desired cross-sectional shape. The pipe member may be formed into the top panel 32 during a molding process, or may be a defined by forming a channel in the top panel 32 during a molding process.

The second heat exchanger 24 includes a blower 52 and a set of cooling fins 54 through which the heated liquid passes and the blower forces air against to heat

the blown air. The third heat exchanger 26 includes a flooring 56, such as a cement floor of a home, and liquid-filled conduit coils 58 embedded in the flooring 56. The passage of liquid from the first heat exchanger through the second heat exchanger 24 defines a first heat exchanging loop 28, and the flow of liquid between the first heat exchanger 14 and the third heat exchanger 26 defines a second heat exchanging loop 29.

When using the hydronic heating system 10 for the purpose of transferring heat generated in the heating appliance 12 to a remote location, heat is generated in combustion chamber 42 and the heat is transferred to the liquid within conduit coils 50 of the first heat exchanger 14. The heated liquid is then moved into the pressure regulating tank 16 and the pressure release valve 22 directs the heated liquid to either the first or the second heat exchanging loop 28, 29.

When the heated liquid is directed into the first heat exchanging loop 28, the first pump 18 pumps the heated liquid through the second heat exchanger 24 where the blower 52 moves air across the cooling fins 54 to transfer the heat held by the heated liquid to the air that is passing over the cooling fins 54. The heated air may be injected into a central heating system or may be used for other heating purposes. The cooled liquid is then pumped back to the heating appliance 12 where it is again heated by heat produced in combustion chamber 42.

When the heated liquid is directed into the second heat exchanging loop 29, the second pump 20 pumps the heated liquid through the third heat exchanger 26. Heat carried by the heated liquid is exchanged between the heated liquid and the flooring 56 as the liquid-filled conduit coils 58 travel through or adjacent to the flooring 56. The heated flooring 56 absorbs heat from the coils 58 and radiates the absorbed heat into the living space. The cooled liquid in second heat exchanging loop 29 is then pumped back to the first heat exchanger 14 where the liquid is again heated by heat generated in the combustion chamber 42.

Although two common heat exchanger structures are shown in the example of Figure 1 as heat exchangers 24, 26, other types of heat exchangers may be used and alternative features may be added to the hydronic heating system 10. For example, the heat transferred by the hydronic heating system 10 may be used for

heating hot water in a hot water heater, a hot tub, a humidifier, or other appliances that require a heated liquid.

Example

In an example hydronic heating system application, the heating system is used to heat a 1,500 square foot room having 8 foot ceilings and a cement floor. Liquid-filled conduits are embedded in the cement floor and coupled to liquid-filled conduits embedded in a panel of a combustion chamber enclosure of the heating appliance. The liquid being heated in the hydronic heating system is a mixture of about 50% water and 50% glycol and is carried in half-inch HEPEX™ tubing between the heating appliance and the cement floor. The desired temperature of the air in the room is 70° F and the temperature outside of the room is 11° F. In order to heat the room to the desired temperature, the heating appliance generates about 13,300 BTUs/hour to generate a liquid temperature in the liquid-filled conduits of the combustion chamber enclosure of about 80° F. The heated liquid is pumped to the liquid-filled conduits of the cement floor at a flow rate of about 2.9 gal/min to heat the cement floor to about 73° F. Heat radiating from the cement floor raises the air temperature in the room to the desired temperature of about 70° F.

Referring now to Figures 2 and 3, an example hydronic heating system 100 is shown including a heating appliance 112 and a heat exchanger 114. The heating appliance 112 includes a combustion chamber enclosure 130 that includes top and bottom panels 132, 134, first and second side panels 136, 138, and a rear panel 140 that define a combustion chamber enclosure 142. A heat generating device such as a burner 148 is positioned within the combustion chamber enclosure 130, and an exhaust 146 is provided for exhausting out combustion gases or other unwanted by-products of generating heat in the combustion chamber enclosure 130.

The heat exchanger 114 includes a plurality of liquid-filled conduit coils 150 that are embedded within the top panel 132 of the combustion chamber enclosure 130. The conduit 150 includes an inlet 151 and an outlet 151 to move cooled liquid into the heat exchanger 114 and move heated liquid out of the heat exchanger 114.

Referring now to Figures 4-6, another example hydronic heating system 200 is shown including a heating appliance 212 and a heat exchanger 214. The heating appliance 212 includes a combustion chamber enclosure 230 having top and bottom panels 232, 234, first and second side panels 236, 238, and a rear panel 240 that define a combustion chamber 242. Heating appliance 212 includes an exhaust 246 and a burner 248 that functions as a heat generating unit. The heat exchanger 214 includes a plurality of liquid-filled conduit coils 250 having an inlet 251 and an outlet 252. The conduit coils are embedded within the top, first and second side, and rear panels 232, 236, 238, 240. Positioning conduit coils in more than one panel of the combustion chamber enclosure may increase the ability of the heat exchanger 214 to absorb heat from the combustion chamber 242 as compared to the heat exchanger 114 of the system 100 that includes embedded conduits in a single panel.

Referring now to Figure 7, another example hydronic heating system 300 is shown. System 300 including a heating appliance 312 that includes a combustion chamber enclosure 330, an outer enclosure 370, and a heat exchanger 314. The combustion chamber enclosure 330 includes top and bottom panels 332, 334, at least one side panel 336, and a rear panel 340 that define a combustion chamber 342. A burner 348 is positioned in the combustion chamber 342 and functions as a heat generating unit. A co-axial vent 345 provides an exhaust vent 346 for exhausting combustion gases out of the combustion chamber 342, and a combustion air vent 347 that provides a fresh combustion air flow B into the combustion chamber enclosure 342 for combustion of fuel at the burner 348.

The outer enclosure 370 includes top and bottom panels 372, 374 and a rear panel 378, and may further include first and second side panels (not shown). A plenum 380 defined between the combustion chamber panels 332, 334, 340 and the outer enclosure panels 372, 374, 376 is designed for the movement of an air flow A around the combustion chamber enclosure to heat the air when combustion is occurring in the combustion chamber 342. A blower (not shown) may be positioned in the plenum 380 to draw cool air into the plenum and expel the heated air out of the plenum.

The heat exchanger 314 includes a plurality of liquid-filled conduit coils 350 embedded within a panel 360 that is coupled to an exterior surface of top panel 372 of the outer enclosure 370. In other embodiments (not shown), the heat exchanger 314 may be positioned within the plenum 380 or may be coupled to other panels of the outer enclosure 370. The heat exchanger 314 may be used to absorb heat generated in the combustion chamber 342 that passes through the combustion chamber enclosure panels 332, 334, 336, 340. In other embodiments, separate heat exchangers that each include a set of fluid-filled conduit coils embedded in a panel distinct from the combustion chamber enclosure may be positioned at various locations around the combustion chamber 330, the plenum 380, and the outer enclosure 370. The heat exchanger(s) of the heating appliance 300 is configured to absorb heat generated in the combustion chamber 342 into the liquid-filled conduits 350 for transport to a remote heat exchanger.

Referring now to Figure 8, another example hydronic heating system 400 is shown and includes a heating appliance 412 and a heat exchanger 414. The heating appliance 412 includes a combustion chamber enclosure 430 having top and bottom panels 432, 434, first and second side panels 436, 438, and a rear panel 440 that define a combustion chamber 442. Heating appliance 412 includes an exhaust 446 and a burner 448 that functions as a heat generating unit. The heat exchanger 414 includes a plurality of liquid-filled conduit coils 450 embedded within a panel 460 that is coupled to the top panel 432 within the combustion chamber 442. In other embodiments, the heat exchanger 414 may be coupled to any of the combustion chamber enclosure panels 432, 434, 436, 440 within the combustion chamber 442, or two or more heat exchangers may be coupled to separate panels of the combustion chamber enclosure 430 within the combustion chamber 442. The heat exchanger of the heating appliance 400 is configured to absorb heat generated in the combustion chamber 442 into liquid held in the liquid-filled conduits 450 for transport to a remote heat exchanger.

The heating system 400 may also include another heat exchanger 415 that includes a plurality of liquid-filled coils 451 embedded within a panel 461. The heat panel 461 is shaped to extend around at least a portion of exhaust 446 and configured to absorb heat emanating from exhaust 446 into the liquid held in coils 451.

Although not show, the heating systems described above may include heat exchanger having panels and coils that are configured for mounting at other locations relative to the source of heat. For example, a heat exchanger panel may be mounted below a bottom panel of a combustion chamber enclosure or below a burner plate within a combustion chamber enclosure. In another example, the heat exchanger panel may be integrated into an outdoor fire pit or fire pit surround.

It is a well known physical property of gaseous substances to rise when heated. This principle applies in heating appliances that include a combustion chamber enclosure, such as the device shown in Figures 1-6, wherein heated air and hot combustion gases rise toward the top portion of the combustion chamber. As a result, it is common that some of the highest temperatures in a combustion chamber enclosure exist near the top part of the combustion chamber. However, high temperatures also occur adjacent to the source of heat in the combustion chamber, for example, adjacent a flame emitted from a burner in a gas fireplace, which results in high temperatures at certain locations on the side and rear panels of a combustion chamber enclosure that are adjacent to the heat source. These heating principles may be exploited for maximizing heat transfer in a hydronic heating system, for example the hydronic heating systems described above. The liquid-filled conduits of the heat exchanger associated with the heating appliance may be embedded within one or more panels of the combustion chamber enclosure or in independently mounted panels in areas of the combustion chamber enclosure that coincide with the highest heating areas.

In the hydronic heating systems 10, 100, 200, 300, 400 described above, the liquid-filled conduits of the heat exchanger associated with the heating appliance are described as being embedded within at least one panel of the combustion chamber enclosure of the heating appliance. More generally, such conduits of the heat exchanger are integrally formed with at least one panel of the combustion chamber enclosure so as to be a single unit. In yet other embodiments, the conduits are defined by material of the combustion chamber enclosure, wherein the combustion chamber enclosure material includes insulating properties, or at least properties that promote a substantially linear temperature transition across the material thickness between the liquid in the conduits

and the heated air of the combustion chamber so as to reduce the possibility of condensation forming in association with the heating appliance.

One way in which the combustion chamber enclosure panels and the conduits of the heat exchanger may be constructed includes forming those features using a moldable material, for example, a moldable material that includes an inorganic ceramic fiber and a binder or other type of high temperature moldable material or fiber. A molded feature of the heating appliance may be formed using any known molding process, such as, for example, compression molding, vacuum molding, or casting processes. Exemplary molding compositions and forming techniques are described in pending U.S. Patent Application Publication No. 2003/0049575 and U.S. Patent Nos. 5,941,237; 5,996,575; and 6,170,481, which patents and patent application are incorporated herein by reference in their entirety.

The use of moldable material may provide several advantages over other types of materials. For example, when using moldable materials for a combustion chamber enclosure, all panels of the enclosure may be formed simultaneously as a single, unitary piece. Another important advantage of using such moldable materials is that the conduits may be directly and integrally formed within panels of the combustion chamber enclosure during the molding process. This provides many design options including intricate conduit designs and positioning arrangements relative to the panels to help position the conduits at the regions of highest temperature within the combustion chamber enclosure. An advantage of using an inorganic ceramic fiber material is the fiber's resistance to the formation of condensation when a cool liquid is in contact with the molded material on one side of the molded piece while a high air temperature condition exists on an opposing side of the molded material piece due to heat within the combustion chamber. Reducing and/or eliminating such condensation provides a more aesthetically pleasing heating appliance, in particular when the heating appliance is a fireplace that is viewable through a front surface thereof for viewing within the combustion chamber. Condensation within a combustion chamber is typically out of character with a heating appliance and may cause stains or discoloring of the heating appliance and may ultimately cause damage to the heating appliance.

Other types of material besides moldable materials may be useful for providing a condensation resistant barrier between the liquid-filled conduits and the combustion chamber or other features associated with the fireplace. Such material may be positioned adjacent to the liquid-filled conduits or between the liquid-filled conduits and the combustion chamber so as to provide a desired condensation barrier.

In some embodiments, portions of the liquid-filled conduits may be at least partially encapsulated in a condensation resistant material, and the encapsulated conduits positioned inside or outside of the combustion chamber enclosure or the outer enclosure of the fireplace, or within a panel of one of those enclosures. In other embodiments, the liquid-filled conduits may be encapsulated with different materials along different portions of the conduit length, or may have multiple layers of encapsulation with different material defining separate encapsulating layers.

The present invention should not be considered limited to the particular examples or materials described above, but rather should be understood to cover all aspects of the invention as fairly set out in the attached claims. Various modifications, equivalent processes, as well as numerous structures to which the present invention may be applicable will be readily apparent to those of skill in the art to which the present invention is directed upon review of the instant specification.